AGE-RELATED DIFFERENCES IN THE USE OF PRESUPPOSITIONAL AND PHONOLOGICAL REDUNDANCY RULES IN SEMANTIC MEMORY

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Audrey Mace Fullerton

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Approved:

Anderson D. Smith, Chairman

Charles Riche

Heidi Rockwood

Date approved by Chairman 2/14/1978

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SUMMARY

Experimentation has shown that older subjects have difficulty using rules of phonological redundancy, rules which aid in the comprehension of language. Experiment I was designed to investigate the possibility that the deficit is not due to the loss of ability to use phonological redundancy, but is rather due either to a retrieval problem or to the confounding of phonological with syntactic and/or semantic redundancy. A tachistoscopic reaction-time paradigm was used in order to minimize retrieval. Letter strings of low approximation to the English language served as stimuli to ensure that the redundancy was phonological. Results showed a clear effect of redundancy for both old and young age groups.

Experiment II was designed to extend the investigation to the use of syntactic redundancy in three adult age groups. Isolated presuppositional sentences were presented, systematically controlled for sentences and construction type. Presuppositional sentences can be divided into two portions, one containing "given" information and one "new" information. It has been shown that younger subjects will remember the "new" portion more reliably than the "given" portion, presumably because the "given" item serves as an address to information already in memory and is not stored a second time.

Several hypotheses were made concerning the number of "given" versus "new" items which might be remembered by subjects of increasing age. Results showed that all age groups recognized more "new" than

"given" items, although the absolute number of items recognized was lower in the older groups for both "given" and "new". In addition, a significant interaction was found between age and the memory for given-new items. Older subjects were found to recognize relatively more "new" than "given" items. It was suggested that the ability to use syntactic redundancy may serve to compensate to some extent for memory deficits commonly found in older subjects.

CHAPTER I

INTRODUCTION

Redundancy in language is used by both speakers and listeners to facilitate rapid and accurate comprehension of a message (Taylor, 1976). Users of the language learn various types of redundancy rules based on the structure of the language as it is stored in semantic memory (Anderson and Bower, 1973). Redundancy rules express how one component of language implies another component (Clark & Clark, 1977). Such rules include: 1) phonological rules, or knowledge of which letter combinations occur most often; 2) rules of syntactic structure important in the organization and thus, comprehension of language; and 3) semantic rules concerning which words are most likely to occur together in meaningful text or speech sequences. Users of a language who are unable to utilize rules of redundancy would be at a disadvantage in comprehending or producing language.

There is some evidence that the ability to use such rules is related to age. For example, Spitz (1972) examined the effects of redundancy on digit span performance of retardates and normal children and found that as mental age increases so does the capacity to discover redundancy in verbal material. In addition, Craik (1968) found that older subjects do not use the redundancy inherent in the English language as well as do younger subjects. If this is the case, older subjects would have more difficulties with communication than younger subjects. Experimental evidence for or against such a deficit in older subjects seems needed.

Craik's (1968) experiment examined the ability of a subject to predict what letter would occur next in a sentence. Each subject was required to guess all the letters and spaces in a sentence from first to last. Older subjects made more guesses before each successful prediction and also had longer reaction times than did younger subjects.

Craik (1968) suggested two possible reasons for these results. The first possibility is that older subjects have lost knowledge of the rules of redundancy, that is, the rules allowing correct prediction in such a task. The second possibility is that older subjects have a retrieval problem when asked to predict the next letter in a sentence and are therefore unable to effectively produce the letters. Memory research has provided support for such an hypothesis (cf. Craik, 1977). The first experiment described below is designed to examine use of phonological redundancy in subjects of different ages using a methodology in which retrieval is not a component. This allows empirical separation of Craiks' two explanations.

It is also important to distinguish between the use of phonological, syntactical, and semantic redundancy. Taylor (1976) points out that constraints within words are mostly phonological and articulatory while constraints between words and between sentences are mainly semantic. Speakers of the language learn to make inferences concerning the meaning of a sentence on the basis of syntactic information obtained from context (Kintsch, 1974). It is not clear which types of redundancy were involved in Craik's (1968) experiment. As noted above, Craik (1968) had his subjects generate a sentence by guessing each consecutive letter. Within each word, the redundancy was probably phonological, but between words and especially as the end of the sentence was reached, the redundancy would be syntactic, semantic, or both.

Carrow and Mauldin (1973) have suggested that the distinction between phonological and semantic redundancy is important developmentally. They found that four and five year old children are able to use phonological redundancy before they are able to use semantic redundancy. Carrow and Mauldin alternatively suggest, however, that these results could be due to difficulty with chunking of verbal material.

Experiments designed to investigate the use of phonological redundancy alone, such as Carrow and Mauldin (1973) above, use word or letter strings which have been statistically generated to approximate the English language to various degrees. A zero-order approximation string sequences the letters such that each of the 26 letters in the alphabet appears with equal probability; a first-order approximation uses the letter frequencies found in printed text; a second-order approximation uses bigram frequencies, etc. As the orders of approximation increase, the letter strings more closely resemble ordinary English (Hirata & Bryden, 1971).

A similar technique has been used by Miller and Selfridge (1950) to generate word strings. It has been suggested (e.g. Salzinger, Portnoy, & Feldman, 1962; Coleman, 1963; Tejirian, 1968) that the orders of approximation to English show syntactic redundancy only through the second order of a word string. The redundancy from that point becomes semantic. Such a distinction may also be applicable to letter strings. It seems reasonable to suppose that the last half of a word or sentence generated letter by letter as in Craik's (1968) task will contain more semantic redundancy than the first half of such a word ot sentence. Experiment I below will use only orders 0-3 of the Hirata and Bryden (1971) letter strings as stimuli in order to investigate the use of phonological redundancy unconfounded by semantic redundancy.

Another common type of redundancy, which will be investigated in Experiment II, occurs when information needed to understand a specific sentence is contained in a previous sentence. Two or more related sentences then constitute a semantic unit. Such redundancy is basically syntactic because an isolated sentence can be constructed in such a way that the listener automatically makes an inference concerning the meaning of the sentences. Such an inference is called a presupposition (Bates, 1976). In general, a presupposition is information known or verifiable to both speaker and listener which is commented on but not directly stated in the sentence (Bates, 1976). There are several types of syntactic constructions which produce presuppositions (Hornby, 1974). For example, in the sentence: "The one that is petting the cat is the girl", the presupposition is that the cat is being petted by someone. The sentence carries the information that this someone is "the girl."

It has been suggested (Hornby, 1974) that the presuppositional information in sentences can be termed the "given" because it refers to information which the subject has presumably already obtained. Any remaining information in the sentence can then be termed "new." In a normal contextual situation, "given" information would have occurred as "new" information in a previous sentence. In an isolated sentence, however, syntactic construction indicates which information is "given" and which is "new." In the example above, the "given" information is that the cat is being petted, while the "new" information is that the girl is doing the petting. Speakers of the language learn to use syntactic redundancy to make inferences concerning sentence meaning. "Given" information, presumed to have occurred in previous sentences, is distinguished from "new" information on the basis of syntactic structure. The distinction between "given" and "new" information in isolated sentences has implications for how sentences are stored in semantic memory.

Offir (1973) suggests that once an assertion has been stored in memory, it might not be stored again when it subsequently appears as a presupposition. In other words, users of a language will learn to look for the "new" portion of a sentence and to record that information in memory more consistently than they record "given" information. Such a learned rule should carry over when isolated sentences are presented (Singer, 1976). Following the presentation of isolated sentences containing grammatical presuppositions, Singer (1976) used the nouns from those sentences in a recognition test. He found that nouns from the "new" portion of the sentence were recognized more frequently than nouns from the "given" portion. For example, the nouns "cat" and "girl" would be tested in the case of the sentence given above: "The one that is petting the cat is the girl." "Girl" would then be recognized more frequently than "cat."

Singer's (1976) experiment indicates the importance of syntactic constructions in memory for sentence components. Thus, it has implications for current research in the area of sentence memory. In one recent experiment, Bransford and Franks (1971) suggest that a sentence is stored in memory as a network of ideas or "propositions." They presented a series of four sentences to subjects, each containing one main proposition. On a subsequent sentence recognition task, they included the original sentences, but also new sentences containing combinations of propositions from previously presented sentences. For example, if two of the original sentences were: "The ants are red" and "The ants are on the table", the new sentence in the recognition task might be: "The red ants are on the table." It was found that subjects not only remembered the combinatory sentences better, but stated that they did so with high confidence. These results indicate that in the storage and later retrieval of information from a sentence, the syntax of the sentence is relatively unimportant compared to the semantic structure. However, Singer and Rosenberg (1973) point out that the central idea (or, in syntactic terms, the main relation) of a sentence is remembered best. They suggest that the high confidence scores given to the sentences combining the propositions of other sentences in Bransford and Franks' study may be due to the fact that such sentences contained the main relation. This would mean that the syntax of a sentence does have some effect on the way a sentence is stored in semantic memory.

Haviland and Clark (1974) suggest still another interpretation of Bransford and Franks' results which also indicates the importance of syntactic structure. They point out that the Bransford and Franks' sentences contain definite noun phrases. "The" in a sentence is a presupposition in the sense of assuming the existence of a specific person or object to which the sentence refers. Thus specific noun phrases act to connect sentences in a common context. Haviland and Clark suggest that if indefinite articles had been used, the subjects might have been less likely to combine the various propositions into a single network.

Walsh and Baldwin (1977) have shown that although older subjects do not remember as many sentences as younger subjects, the same tendency is shown to "remember" never-presented sentences if the sentences contain several propositions actually presented separately. In other words, on a Bransford and Franks task, there is no interaction between age and memory for propositions. In this task, however, the presuppositional information given by use of the definite articles is simply that the elements of the various sentences are related. This information is not redundant in the same manner as is that information contained in the type of syntactic presupposition used by Singer.

Haviland and Clark (1974) suggest that the redundancy in the "given" portion of a sentence may have a purpose other than to gain accuracy in noisy environments, the purpose generally attributed to redundancy in language (Taylor, 1976). Instead, "given" information, although redundant, may be necessary as a method of access to relevant information already stored in memory. Under ordinary contextual conditions, once access is obtained, the information in the presuppositional portion of the sentence is found to be already stored and so is not ordinarily stored again. In other words, the language user learns that certain syntactic constructions indicate the presence of redundant information which is already stored in memory. Therefore, subjects who are able to use the rules of redundancy should be more likely to store information contained in the "new" portion of an isolated sentence than that contained in the "given" portion. Conversely, subjects who are unable to use redundancy rules should make no distinction between the "given" and the "new" portions of an isolated sentence.

Craik (1968) found that older subjects have more difficulty using the redundancy of language than younger subjects. It is not clear from his experiment, however, which types of redundancy were involved. If the deficit is in the use of syntactic redundancy, it might be shown by an inability to use syntactic redundancy in an isolated presuppositional sentence. That is, if older subjects are less able to use syntactic redundancy, they might tend to remember the "given" portion of a sentence to the same extent as they remember the "new" portion, in contrast to Singer's (1976) results with younger subjects.

However, there are other possible results in such an experiment that would be due to factors other than redundancy. For example, Arenberg (1968) found that older subjects are less likely to remember negative instances in a concept attainment task. He hypothesized that because negative instances contain less information than positive instances, the negative instances will more likely be forgotten first if too many demands are made upon memory. If this hypothesis is correct, then older subjects would be less likely than younger subjects to store the "given" information in memory because they have learned that the "given" portion of a sentence contains less information.

Singer's results can also be explained in terms of sentence comprehension. As Carpenter (1974) points out, comprehension of a sentence has two subprocesses: coding and integrating. She suggests that if a subject does not comprehend a sentence, it may not be encoded properly and therefore would not be recalled as well. In this regard, Brewer and Harris (1974) found that episodic words (e.g., words referring to time and place) are more difficult to recall than nonepisodic words when sentences are presented in isolation. Their interpretation of this result is that the episodic words are less meaningful out of context, and less meaningful material is not remembered as well as more meaningful material. It is possible that a reason why the presuppositional part of an isolated sentence is not remembered as well is that it is less meaningful than the "new" portion of a sentence. If older subjects have more difficulty comprehending a sentence, then, in contrast to younger subjects, older subjects should remember "given" information no better, but no worse, than "new" information.

There are, then, three possible results to be found when the memory of older subjects is tested with isolated sentences containing presuppositions. The first possibility is that the older subjects may remember the "given" portion of the sentence as well as they remember the "new" portion. This result could occur either because older subjects do not use the rules of syntactic redundancy or because they have not comprehended the sentence. In other words, in either case, older subjects would remember as many (or as few) "given" nouns as "new" nouns. That is, in the example above, older subjects would remember "cat" as frequently as "girl."

The second possibility is that older subjects will remember the "given" portion of a sentence less well than younger subjects. This would occur if the salient difference between the "given" and "new" parts of the sentence is that the former contains less information and if the memory of older subjects is taxed by the experimental task. The difference between recognition of "given" and "new" nouns would then be greater for older subjects than for younger ones.

The third possibility is that there will be no interaction between age and the number of "new" and "given" nouns recognized on a test. This would occur if the presuppositional portion of the sentence is less meaningful to both groups and thus not as well remembered as the rest of the sentence. It would also occur if elderly subjects have not lost the ability to use syntactic redundancy. These hypotheses are depicted in Figure 1.

Experiment I examines the use of phonological redundancy rules by older subjects. It is not clear from Craik's (1968) experiment whether older subjects were unable to use the rules of redundancy, whether phonological, syntactic, or semantic, because these rules had been forgotten or because of a retrieval difficulty. Also, it is not clear which types of redundancy were involved. A tachistoscopic

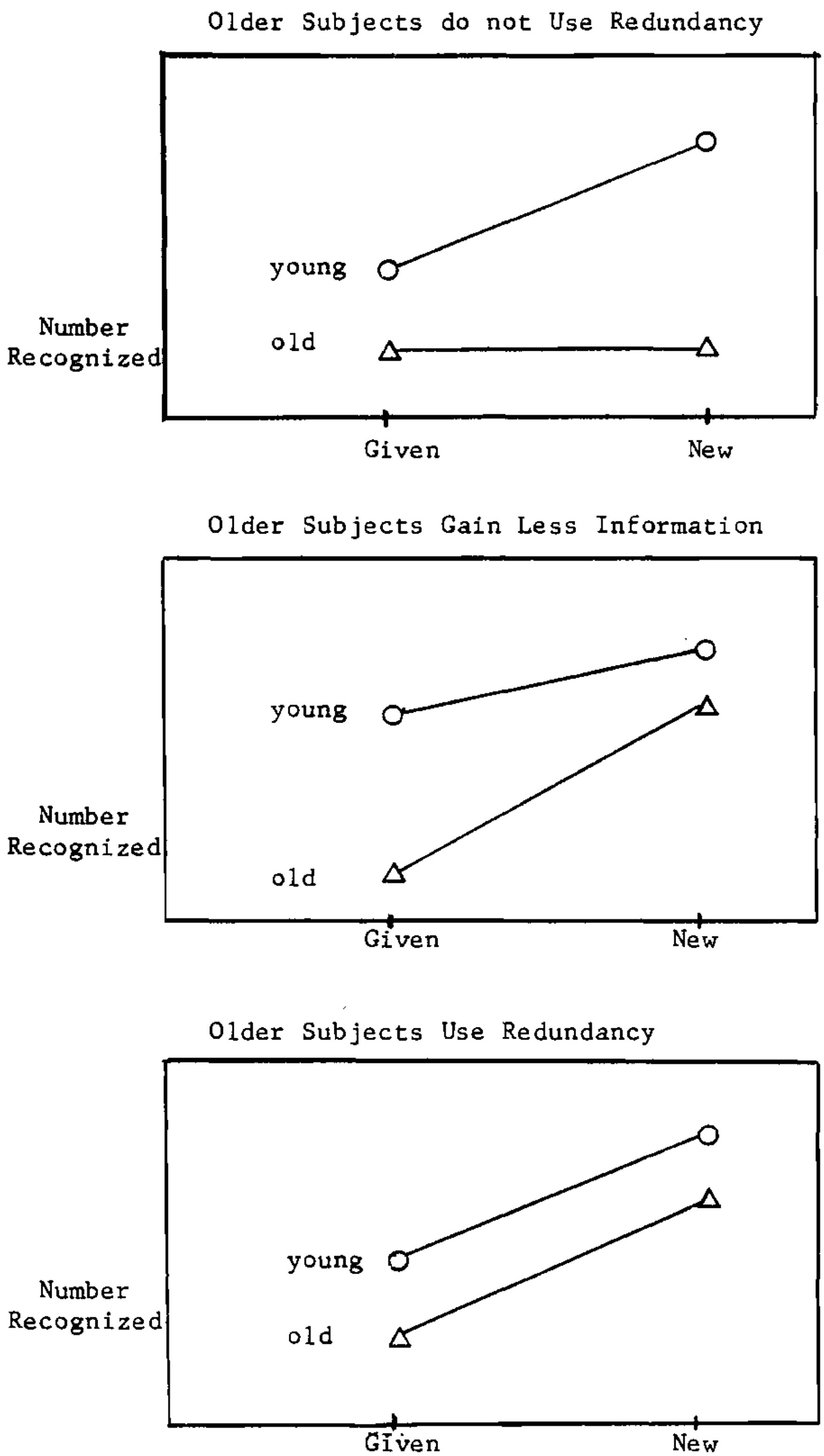

Figure 1. Hypotheses for Experiment I

reaction time experiment is suggested to investigate the use of phonological redundancy rules in a situation similar to the everyday use of such rules, as in reading. The letter strings developed by Hirata and Bryden (1971) to approximate the phonological structure of the English language at various orders are used as stimuli. Use of these stimuli should avoid the confounding of syntactic and semantic redundancy with phonological redundancy which occurred in Craik's (1968) experiment. Only orders zero through three are presented, as the higher orders of letter strings are more likely to be confounded with semantic redundancy. Subjects who do not use phonological redundancy rules should show reaction times which are as large for the higher orders as for the lower ones. Subjects who do use such rules, on the other hand, should show decreasing reaction times as order increases.

The experiment is designed in such a way as to be able to determine whether Craik's (1968) results were due to a retrieval problem rather than to inability to use redundancy. A single letter is presented tachistoscopically, followed by a letter string. The subject is asked to determine whether the letter appears in the string. The subject who is able to use phonological redundancy rules should be able to locate the letter or to determine its absence more quickly as order increases, since at higher orders the subject will have more information as to where that particular letter should appear in the letter string.

Syntactic redundancy rules used in interpreting and recalling components of sentences are investigated in Experiment II. Specifically, this experiment, using the recognition paradigm developed by Singer (1976), examines age differences in the use of syntactic redundancy in interpreting sentences. The syntactic redundancy in this experiment consists of presuppositions which have been built into isolated sentences through various syntactic constructions, as for example, the sentence described above: "The one that is petting the cat is the girl."

In summary, Experiment I is designed to look at phonological redundancy within words. Semantic redundancy is controlled and retrieval minimized. The second experiment investigates the use of syntactic redundancy in larger units of the language, specifically investigating the use of presuppositions in sentences. Little research has been conducted looking at age differences in semantic memory and interpretation of sentences. The experiments described below investigate age-related differences in these important areas of cognitive functioning.

CHAPTER II

EXPERIMENT I - PHONOLOGICAL REDUNDANCY

Subjects

Subjects were 16 healthy active male and female residents of an apartment complex for retirees, ranging in age from 62 to 92 (Mean Age = 77.13), and 32 male and female undergraduates at The Georgia Institute of Technology, ranging from 18 to 29 years (Mean Age = 20.47). The older subjects were paid five dollars each for participation. The students received experimental credit in their introductory psychology classes.

Materials and Procedure

Subjects were run individually, the students in the psychology laboratory at Georgia Tech, and the older subjects in an isolated room at the apartment complex. Subjects sat at a table before a screen on which materials were projected by a Kodak Ektagraphic slide projector. The slide projector was connected to a tachistoscopic lens which was in turn connected to a Hunter timer in order to regulate presentation of the slides. The first slide contained a single letter, presented for two seconds. The second slide, containing a letter string, was presented for a maximum of five seconds. Two microswitches were also connected to the timer, one on each side of the projection screen. As soon as the decision was made by the subject as to whether or not the single letter appeared in the letter string, the subject was in-structured to press the switch on the right side of the screen to indicate a "yes" answer or the switch on the left side to indicate a "no" answer. (Left-handed subjects were given reverse instructions, being told to use the left switch for "yes" and the right for "no.") As soon as the microswitch was pressed, the timer stopped and the lens shutter closed. Reaction time was manually recorded by the experimenter in milliseconds. The subjects were told that the decision was of primary importance, but that then speed became important. Because the letter string was available to the subject when the decision was made, any retrieval problem with the letter string was eliminated. The procedure for Experiment I is depicted in Figure 2. The instructions are provided in Appendix 1.

The stimuli consisted of 32 letter strings, eight chosen at random from each of the first four orders of approximation of Hirata and Bryden (1971), and 32 single letters. Of the single letters, four from each order appeared in the letter string which followed each individual letter, and four did not. Aside from this constraint, all letters were chosen randomly. The Hirata and Bryden (1971) strings were computer-generated according to the frequency of occurrence in the English language of single, double, triple, and quadruple letter combinations. Strings in the zero order approximation were generated completely at random; first order strings were generated by taking relative frequency of single letters into account; second order strings were generated using relative frequency of double letters, and so forth.

Within each order of presentation, the choice of which strings

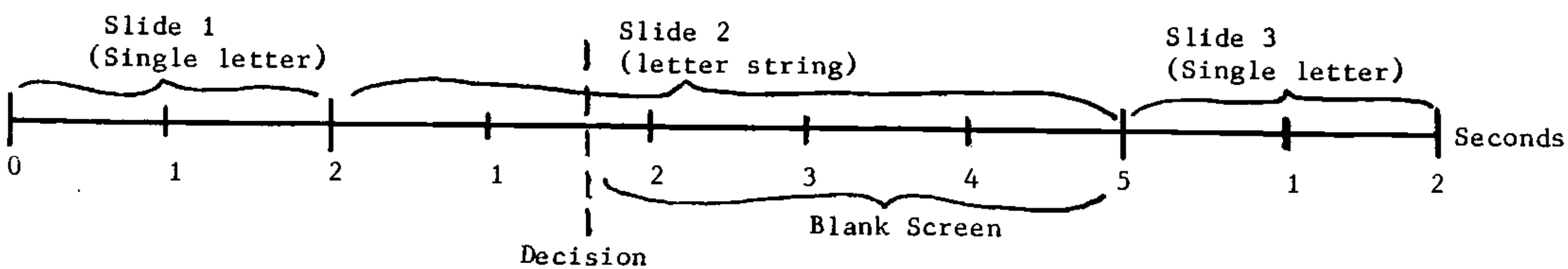

Figure 2. Procedures for Experiment I

contained the previously presented single letter was also random, aside from the constraint that four strings would have "yes" responses and four would have "no" responses. After letters had been assigned to the strings in each order, the entire list of 32 strings was randomly ordered for presentation. All subjects received the same presentation order. The letters and eight-letter strings are listed in Appendix 2.

Results and Discussion

All subjects were native English speakers and were pretested on digit span and vocabulary. Mean digit span scores were 7.28 ($SD = .96$) for the students and 6.63 ($SD = .72$) for the older subjects. The students were subdivided into two groups: those who received the original eight-letter strings (Mean = 7.50; $SD = .82$) and those who received 12-letter strings (Mean = 7.06; $SD = 1.06$). The variances of all three groups were found to be homogeneous. Although the difference between digit spans of the eight-letter college group and the 60+ group was significant ($t = 3.22$, p .005), the difference between the 12-letter college group and the 60+ group was not significant ($t = 1.36$). Since the latter comparison included the two groups on which the redundancy comparison was made, the differences in digit span were deemed to be unimportant.

The vocabulary test score was based on the last 21 items on the Wechsler Adult Intelligence Scale. Mean scores were 21.44 ($SD = 6.77$) for students and 25.06 ($SD = 7.46$) for older subjects. Again the student scores were subdivided into two groups. The eight-letter string group had a mean score of 21.0 (SD = 6.57) while the 12-letter group had a mean score of 21.88 (SD = 7.15). The variances were found to be homogeneous, and no significant differences were found between any two of the groups.

Sixteen college subjects and sixteen older subjects were shown the list of 32 eight-letter strings. For each subject, reaction times were averaged over the correct responses from the eight presentations of each order. These means were then tested by an analysis of variance. Although there was a clear effect of redundancy across the four orders of approximation due to age ($F(1,30)=24.27$, $p < .005$), a floor effect on reaction times occurred in the student group. That is, reaction times might have been so low across all orders that no differences among orders could be shown. Therefore, a second group of 16 college students was shown 12-letter strings. These consisted of the eight-letter strings used for the first group with the addition to each of the first four letters of the string immediately preceding it in Hirata and Bryden's list. Again, all single letters were randomly chosen, aside from the constraint that four did and four did not appear in the following letter string. See Appendix 3 for the list of letters and 12-letter strings.

Lengthening the letter string for the young group had the effect of making reaction times approximately equal for both the young and the old groups, eliminating the significant age effect. The analysis of variance shows, however, that a redundancy effect occurred across the four orders in the college group shown 12-letter strings ($F(3,6)= 9.68$, $p < .05$). See Table 1 for the summary of the analysis of variance.

Table 1. Analysis of Variance Summary Table: Twelve-letter Strings (College) and Eight-letter Strings (60+)

Source	Sum of Squares	DF	Mean Square	F
Between Subjects	17.32	31		
Age	.11	1	.11	.19
Subjects Within Groups	17.21	30	.57	
Within Subjects	1.89	96		
Redundancy	.46	3	.15	9.68
Age x Redundancy	.01	3	.00	.11
Residual	1.43	90	.02	

Figure 3 presents the mean reaction times over the four orders of approximation for each age group.

Since the effect of redundancy was similar in both age groups, once compensation was made for the quicker reaction times of the student group, this experiment indicates that the ability to use phonological redundancy is not lost with age. The results of this experiment correspond with those of a recent study by Elias and Hirasuna (1976) who investigated semantic and phonological encoding in young and old subjects using the release from proactive interference paradigm. Subjects were given four trials in which they were asked to recall three words at a time from a particular category. On the fourth trial, half the subjects (the experimental group) were asked to recall three words from a new category, while the other half of the subjects continued to recall from the same category. Since proactive interference produces a decline in recall across trials when the words come from the same category, release from interference, as shown by a rise in recall rate, indicates that the subject is sensitive to a change in the category. The phonological categories used by Elias and Hirasuna (1976) consisted of rhyme switches, while semantic categories were taxonomic. Elias and Hirasuna found that the amount of release with both semantic and phonological categories was similar in pattern, although not in absolute results, for both age groups. Although the amount of release on rhyme shifts was actually greater for older subjects than for younger subjects, this was interpreted as being due to a smaller proactive buildup in the older group, and thus was not considered to indicate a greater sensitivity to phonological

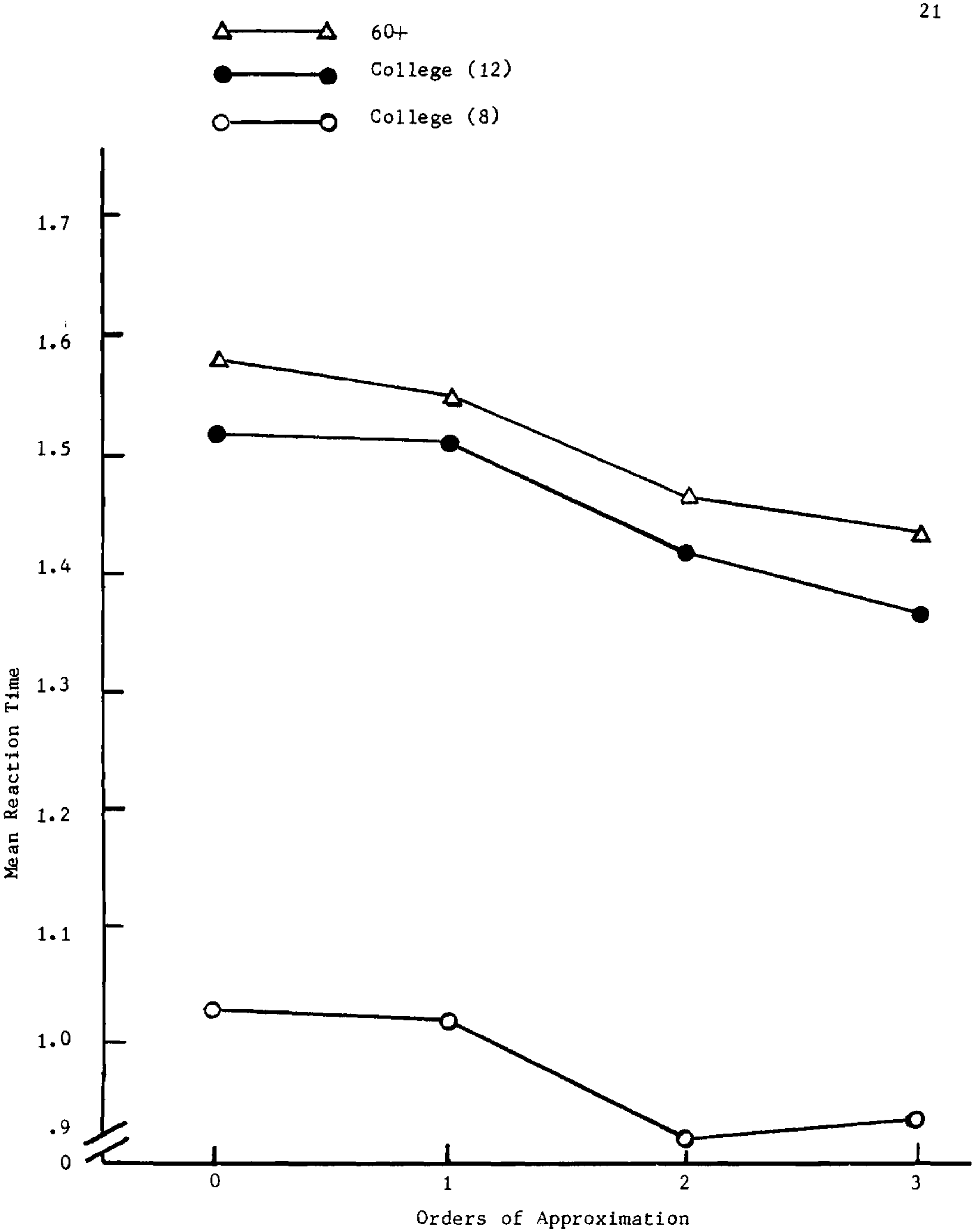

Figure 3. Mean Reaction Times of Three Groups over Four Orders of Approximation

encoding in the older group. Moreover, for both groups, the semantic dimension produced greater proactive release than did the phonological dimension.

As noted above, Craik (1968) has suggested that the relative inability of older subjects to perform his letter-by-letter sentence generation task could be due to either a retrieval problem or to inability to use phonological redundancy. The present experiment shows that ability to use phonological redundancy is not impaired with age. However, since the factor of retrieval was minimized in the present experiment, and the emphasis was placed on encoding, an interpretation of Craik's results in terms of a retrieval problem is still feasible.

Eysenck (1975) found, however, that items from semantic memory are as available to older subjects as to younger subjects. Eysenck used a paradigm similar to that used in this experiment, except that the stimuli were: first, a category name, and second, a single letter (in the recall task) or a category instance (in the recognition task). Subjects were asked to either recall an item from the category with that first letter, or to say whether or not the given instance was a member of the category. There was no significant difference in reaction times between the two age groups in the recall task. However, as in the present experiment, reaction times for recognition were significantly longer for older subjects than for younger ones. Eysenck suggests that since this difference occurred only with the recognition task, it reflects a longer decision process in older subjects rather than a difference in availability between the two groups. A prolonged decision process could not, however, explain the longer times Craik's older subjects took to guess the next letter in the sentence, since this was a recall task, and also could not explain why older subjects made more incorrect guesses than younger subjects.

Another possible explanation of Craik's results could be that older subjects are less able to use syntactic or semantic redundancy to aid in efficient encoding. In this sense, availability and decision would be parallel processes, since a decision would have to be made about each letter in turn. Each such decision would require less time if the learned rules of phonological redundancy were used efficiently. Elias and Hirasuna's (1976) experiment addressed the question of semantic encoding in older subjects and found no decrements in pattern with age, indicating that older subjects are able to use semantic encoding. However, an unimpaired ability to encode on a semantic dimension, as shown in Elias and Hirasuna's (1976) experiment, or to retrieve semantic information from memory, as shown by Eysenck (1975), are not necessarily the same as the ability to use semantic or syntactic redundancy rules for more efficient encoding. It is possible that redundancy in syntactically or semantically encoded materials is not as helpful to older subjects as it is to younger ones. Experiment II below investigates this possibility in regard to syntactic redundancy.

CHAPTER III

EXPERIMENT II - GRAMMATICAL REDUNDANCY

Subjects

266 male and female subjects were drawn mainly from civic and church groups in the Atlanta area. Subjects were divided into three age groups: 20-39, 40-59, and 60 and above. All subjects were run in groups.

Materials and Procedure

Materials consisted of four possible versions of 24 sentence frames from Singer (1976). Four lists of 24 sentences each were produced, each list containing six sentences in each of four syntactic constructions. The basic sentences are presented in Appendix 4. Hornby (1974) pointed out that cleft and pseudocleft constructions are the most likely to produce strong presuppositions. These two basic constructions are further subdivided according to whether the agent or the object of the sentence is the "new" noun. For example, the basic sentence: "The king led the troops", appeared in the following four forms:

It was the king who led the troops. (Cleft agent)

It was the troops that the king led. (Cleft object)

The one who led the troops was the king. (Pseudocleft agent)

What the king led was the troops. (Pseudocleft object)

The 24 sentences in each list were tape-recorded at ten-second intervals.

Each group heard one of the four lists.

Each subject received a booklet and a pencil. The first and second pages (following a cover page) consisted of 24 numbered lines. Each line was divided in three with the word "inactive" at the left, "average" in the center, and "very active" at the right. Subjects were asked to rate each sentence as it was presented by checking the scale for physical activity of the sentence. The physical activity scale is presented in Appendix 5.

Following completion of the tape-recorded list of sentences, subjects turned to the next page of the booklet. Written on this page were sixty pairs of two-digit numbers to be added for a 90-second period. This task eliminates the recency effect and reduces the overall level of recall. The final page of the booklet consisted of 48 words, one each from the 24 sentences plus 24 distractors. The distractors were chosen from the norms of Paivio, Yuille, and Madigan (1968). Each distractor noun chosen had a frequency score of 10 or greater, and concreteness scores of five or greater (Singer's criteria for choice of the original nouns). Recognition lists are presented in Appendix 6. Next to each word was printed a Y and an N, standing for "yes" and "no." Subjects were asked to circle the Y if they recognized the word as having appeared in one of the sentences, and the N if they did not recognize the word. Two recognition lists were used, each consisting of twelve subject nouns and twelve object nouns, as well as three "given" and three "new" items for each syntactic construction. The recognition lists were constructed so that the number of objects and subjects to be recognized from each syntactic construction was the same in both age groups.

Results

Clark (1973) argued that language materials should be treated as random rather than fixed variables, especially when the assumptions of fully-crossed designs are not met. Due to the systematic counter-balancing used in this experiment, such assumptions are not met. That is, the design is not really a factorial, since the recognition lists are nested in the sentences, the same recognition lists being used for sentence lists one and three, and also for two and four. Therefore, Singer (1976) suggested that two analyses are needed for the present experiment, one treating subjects as the random variable, and the other treating sentences as the random variable. Wike and Church (1976) further point out that even if Clark's view of treating language materials as random effects is not accepted, it is still a valid and useful procedure to test treatment effects with respect to variability in both subjects and language materials. Accordingly, the first analysis for Experiment II treated subjects as the random variable and collapsed across sentences.

Eight construction types were used in the sentence lists, including agent and object sentences for both cleft and pseudocleft sentences. For example: "It was the nun who cleaned the bowl" is a cleft sentence in which the subject (agent) of the basic sentence appears as the "new" item. In contrast, in the sentence "It was the potato that the dove found", the "new" item is the object of the basic sentence. Pseudocleft sentences were also constructed in this way. For example, "The one who noticed the factory was the fisherman" as contrasted to "What the prisoner visited was the palace." Singer (1976) used these constructions in order to control for the possibility that the subject of a sentence would be remembered better than the object, or vice versa. The two types of sentences, cleft and pseudocleft, were used because Hornby (1974) pointed out that they distinguish given and new items more clearly than does a basic active sentence. In each list of 24 sentences, each sentence type appeared six times, further subdivided by whether the agent or object was the new item. Each of the types was then counterbalanced across the four lists. When the variance was divided into that due to specific sentences and that due to construction type, no significant differences were found. This result indicates that the systematic counterbalancing used in the design succeeded in minimizing any effects due to construction type or sentences. See Table 2 for a summary of the analysis of variance.

The second analysis treated sentences as the random variable and collapsed across subjects. Since difference scores were used for each subject (number of given items recognized subtracted from number of new items) there was no need to correct for "false alarms." In effect, each subject served as his own control. In other words, since each subject used the same criterion for recognition of both "new" and "given" items, adding the same constant as a correction factor for guessing would make no difference to the final result.

All three age groups recognized the new portion of the sentences more reliably than the given portion, a result which replicates Singer's (1976) findings ($F(1,263) = 120.06$, $p < .005$). See Table 3. Since

Table 2. Analysis of Variance Summary Table: Sentences and Constructions by Age Group

Source	Sum of Squares	df	Mean Square	F
Age	2.523	2	1.262	3.220
Constructions	1.112	7	.159	.406
Sentences	3.514	23	.153	.391
Age x Sentences	4.010	46	.087	.223
Age x Constructions	.310	14	.022	.057
Sentences x Constructions	8.917	161	.055	.142
Residual	125.938	322	.391	
Total	146.324	575	--	--

Note. All comparisons except for age were nonsignificant at the .05 level.

Table 3. Analysis of Variance Summary Table: Given-New by Age Group

Source	Sum of Squares	df	Mean Square	F
Given-New	162.48	1	162.48	120.06 [1]
Age Groups	212.40	2	106.20	12.76 [2]
Ss in Age Groups	2188.70	263	8.32	
Age Groups x Given-New	12.62	2	6.31	4.66 [1]
Residual	355.90	263	1.35	
Total	2932.10	531	--	--

[1] Tested against residual

[2] Tested against Subjects in Age Groups

the recognition procedure used in this experiment minimizes the retrieval factor (Kintsch, 1970), it is likely that the difference between recognition of given and new items occurs at the time of encoding. The finding that recognition of old vs. new items was consistently better across all three age groups indicates that all subjects were able to use the syntactic redundancy inherent in an isolated sentence with a presuppositional construction to encode "new" information more reliably than "old" information.

On the other hand, there was a significant age group by given-new interaction ($F(2,263) = 4.66$, $p < .01$). The differences between given-new means for the three age groups were .71 (20-39), 1.48 (40-59), and 1.17 (60+), suggesting that the youngest group uses syntactic redundancy to a smaller degree than the older groups. Given-new means by age are presented in Figure 4.

There was, however, a consistent decrement in absolute number of items recognized across age groups from young to old ($F(2,263) = 12.76$, $p < .005$). That is, the older subjects did not recognize as many items, given or new, as did the younger subjects, and the middle group fell between the two extremes. It has been suggested that decrements in memory in older subjects occur because of a problem with retrieval from memory (Craik, 1968). Such a problem should be minimized by a recognition task (as compared to recall) (Kintsch, 1970). Many studies using recognition tasks to test memory in older subjects have found no difference in their performance as compared to younger subjects (e.g., Schonfield & Robertson, 1966). Such findings indicate that

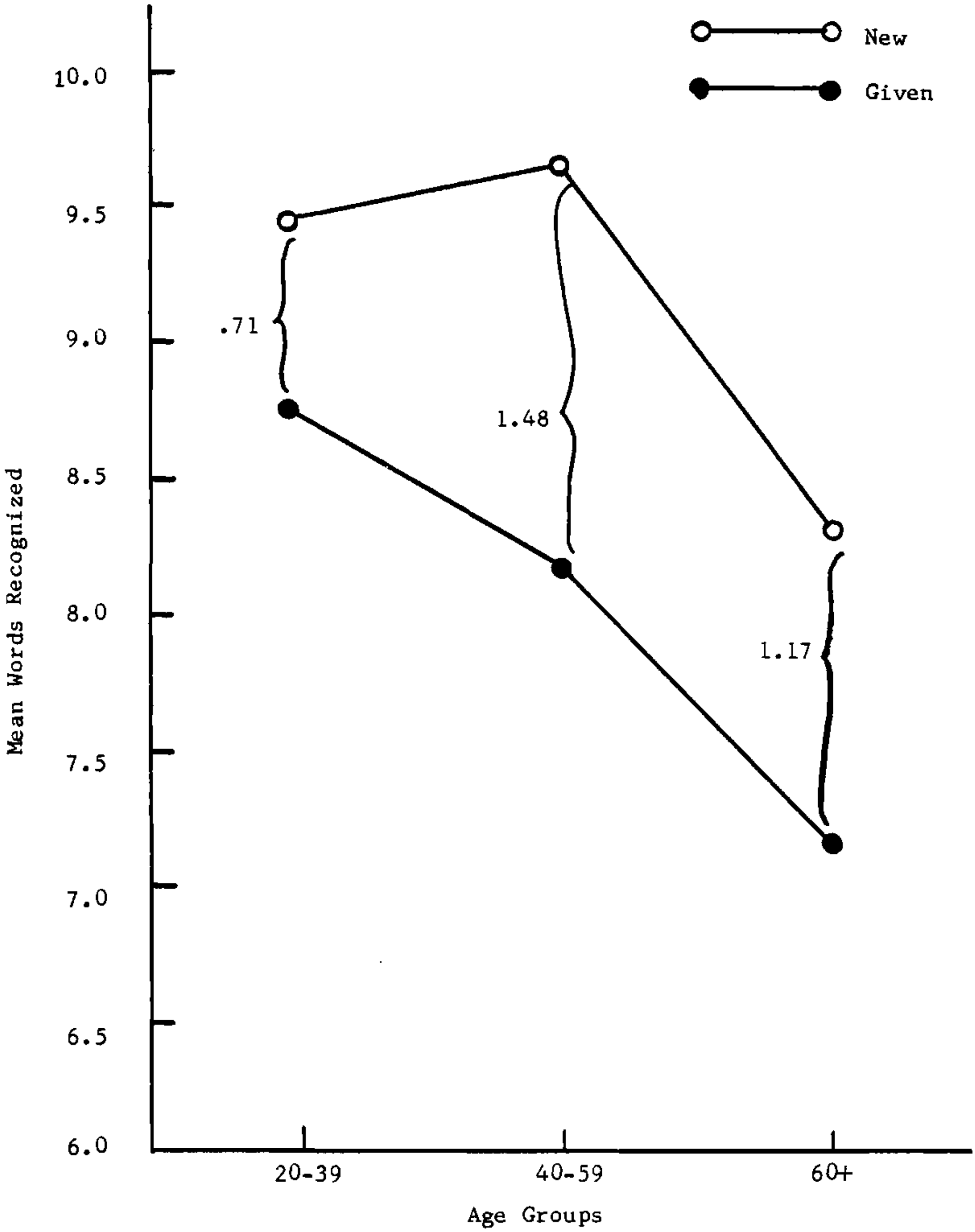

Figure 4. Given-New Means by Age

decrements in recall scores are probably due to a retrieval problem. When a recognition decrement is found, however, as in the present study, it suggests that the locus of the problem may lie elsewhere than in the retrieval process.

Discussion

The results show that all subjects used syntactic redundancy as an aid to memory. The apparent improvement of the memory for new vs. given items with age, however, indicates that another factor besides redundancy may be involved. The finding of a better memory for new items among older subjects, coupled with the decrement in overall recognition, suggests that Arenberg's (1968) hypothesis concerning compensations for memory deficits may be correct. Arenberg found that older subjects are less likely to remember negative instances in a concept attainment task when excessive demands are made upon memory. He suggested that negative instances are forgotten more quickly because they contain less information. Arenberg's results pertain directly to the present experiment, since, if the assumption that subjects are using learned rules of syntactic redundancy is correct, then, by definition, the "given" items contain less information than the "new" items.

The results of the present experiment thus indicate that the syntactic structure of the language may be an aid to increased memory efficiency with age. In other words, the effect of an overall memory decrement with age may be minimized if learned rules of language are used efficiently to discern and encode "important" information.

However, although the difference between memory for "new" items among the age groups was not as great as the difference between memory for "given" items, there was still a significant overall decrease in recognition scores with age. As discussed above, this recognition decrement is probably not due to a retrieval problem.

An alternative explanation could be that the elderly have a tendency to be more cautious in the responses they emit (e.g., Botwinick, 1966). Okus and DiVesta (1976) found that older adults are more likely to choose problems of lower difficulty levels than are younger adults, thus increasing the probability of obtaining a correct answer. They interpreted this result in terms of increased cautiousness with age. In terms of recognition scores, the more cautious subject would have a lower overall "hit" rate than would the less cautious subject, due to higher criteria of the former. Miller and Lewis (1977), for example, using signal detection analysis, found that lower performance on a recognition task by depressed elderly patients was due to a more conservative response strategy rather than to memory impairment. On the other hand, there is some evidence that higher anxiety in older subjects results in lowered criteria and thus in a higher "hit" rate (Clark & Greenberg, 1971). In the present experiment, however, Betas in a signal detection analysis averaged 1.03 for the young group, 1.12 for the middle group, and 1.19 for the old group, suggesting no differences in criterion due to age as measured by this index (Egan, 1958).

A second possible explanation for the decrement in recognition is that it is due to an encoding problem in the older group. Extrapolating from Carpenter's (1974) suggestion that a sentence must be comprehended in order to be encoded, it was suggested in the introduction that comprehension of isolated presuppositional sentences might be hindered in older subjects by the structure, since the "given" portion would be less meaningful. However, since the memory of older subjects for new items was relatively better than the memory of younger subjects, the meaningfulness of the items evidently does not decrease with age. Since sentences have to be comprehended in order to be semantically encoded, further evidence that meaningfulness is not dependent on age is provided by Walsh and Baldwin's (1977) experiment in which they found no age differences between young and old groups in the amount of semantic integration of sentence propositions.

The differential recognition scores obtained in this experiment rather suggest that there are age differences in the relative efficiency of encoding or storage of information (Eysenck, 1974). Gordon and Clark (1974) found age differences in the storage of information. They divided their subjects into two age groups: elderly (Mean = 71.23 years) and young (Mean = 24.76 years). Each subject received two study trials and two recognition trials for lists of words and nonsense syllables. It was found that performance by older subjects became differentially poorer on the second trial. Gordon and Clark suggest that the essential difference between the old and the young groups is in the rapidity with which the memory trace fades. In their study, fading in the older group began when the mean memory trace was between 1.5 and 2.0 minutes old. The mean memory trace in the present experiment was 3.0 minutes old at the time of test, due to the 90 second interval between presentation of the lists and the recognition task. According to Gordon and Clark's analysis, this could be a significant interval in terms of explaining the recognition decrement in the older group, since the memory trace could have faded significantly by the time of test.

Further evidence on this point comes from an experiment by Gordon (1975) which investigated differences between young (Mean = 21.28 years) and old (Mean = 70.74 years) subjects in the organization of related sentences. Although the major test was of recall, a sentence comprehension test was also given which was similar to a recognition test. An encoding and/or storage problem is suggested by the fact that recognition scores as well as recall scores were poorer in the older group. In addition, older subjects did not improve as much as younger subjects between two trials, a result interpreted by Gordon and Clark (1976) as showing more rapid trace fading in older subjects.

The overall result of the present experiment, that "new" information is remembered more reliably than "old" information, clearly indicates the existence of a syntactic component in sentence memory. Such a result conflicts with Bransford and Frank's (1971) finding that sentence "propositions" are integrated solely in terms of their semantic content. As noted in the introduction, it has been suggested that these results are an artifact of the way in which Bransford and Franks presented their sentences. For example, Singer and Rosenberg (1973) suggest that the central idea of a sentence is remembered best and that the central ideas were always presented in Bransford and Franks' complex sentences. In addition, Haviland and Clark (1974) point out that the use of "the" to introduce a noun phrase serves to tie that phrase to all others presented in the sentence series. A recent experiment by Hupet and Le Bouedec (1977) presents evidence in support of these suggestions and therefore can be used to explain the apparent contradiction between the present findings and those of Bransford and Franks.

Hupet and Le Bouedec (1977) found that whether or not subjects integrate sentence ideas depends on the order in which sentences are presented. If the sentences are presented in such a way that antecedents of each sentence in the series are readily located, subjects will integrate the total propositional content of the sentences. Such integration will not occur, however, if sentences are randomly presented. In the latter case, the antecedent of a particular sentence does not occur in the immediately preceding sentence. For example, if the sentence "The horse is white" follows the sentence "The horse is in the pasture", the two sentences will be integrated, since the subject antecedent "horse" appears in both. On the other hand, if the sentence "The horse is white" follows the sentence "The girl ran down the hill", no integration will occur, since the second sentence has no antecedent in the first.

The "antecedent" of a sentence can be compared to the "given" portion of a presuppositional sentence in that both would act as an address to a specific location in memory, as suggested by Haviland and Clark (1974). If information in a sentence can be connected to information already in memory, the "new" information will be integrated with the old. This is the result found in the Bransford and Franks (1971) experiment and in the Hupet and Le Bouedec condition in which sentences are presented in an orderly fashion. On the other hand, if new information cannot be connected to information already in memory, the new information will be stored separately, the result found by Hupet and Le Bouedec when sentences were presented randomly with no clear antecedents. Such an analysis demonstrates the importance of syntactic elements in language (e.g., presuppositional structure; subject or object antecedents) in building up the structure of semantic memory. Moreover, the results of the present experiment suggest that, as age and its concomitant memory problems increase, the ability to use syntactic elements of the language to aid in encoding information into semantic memory may become ever more important.

CHAPTER IV

CONCLUSIONS

Redundancy in language can be divided in at least two ways: 1) by type, that is, phonological, syntactic, or semantic, or 2) by function. Weaver (1977) points out that redundancy can act as an aid to either encoding or decoding of material in memory. When the redundancy is in the incoming message, it can be used to determine which part of the message requires further processing. In other words, redundancy points out "new" or discrepant items in the message which are then acted upon by the person receiving the message. On the other hand, when the redundancy is in the output, it can act as a heuristic search procedure, that is, as an aid to planning the most likely and proper response. Experiments I and II emphasize encoding and therefore are based on the first of these two uses of redundancy.

In an attempt to determine whether older subjects are able to utilize phonological redundancy, Craik (1968) used a letter-by-letter guessing method which was oridinally developed by Shannon (1961) to estimate the amount of redundancy in the English language. There are two major problems with using Shannon's method to measure the ability to use phonological redundancy. The first problem is that this method is not limited to phonological redundancy, but includes syntactic and semantic elements. In contrast, the use of Hirata and

Bryden's (1971) letter strings of low order of approximation to English ensures that the redundancy in Experiment I is primarily phonological.

The second problem of Shannon's method is that it is based on use of a search procedure. In other words, retrieval is an important element. Craik's (1968) results might then be explained as due to a faulty search procedure among older subjects, since they guessed more wrong letters. This suggests that research needs to be conducted on redundancy used during output to determine whether the ability to use learned redundancy rules during encoding differs from the ability to use redundancy during decoding. It is possible that older subjects may have a decrement in ability to use phonological redundancy rules as an aid to decoding as well as a problem with retrieval. In order to separate use of redundancy in decoding from retrieval, the Shannon method could be used, but with the subjects given a list of letters from which to choose the correct option. In Experiment I, however, the ability of different-aged subjects to use phonological redundancy as an aid specifically to encoding is being tested, and the problem of retrieval is minimized by the tachistoscopic reaction time method used. The results show that when allowance is made for slower reaction times of older subjects, the ability to use phonological redundancy during encoding is not lost with age.

Experiment II also investigates the use of redundancy as an aid to encoding of an incoming message, but with emphasis placed on syntactic redundancy. The sentences used in this experiment were constructed by Singer (1976) in such a way as to emphasize both the "given" and "new" portions of each sentence. The result of this experiment replicates Singer's (1976) finding that "new" information is remembered best, presumably because it is encoded more consistently. Such a finding indicates that knowledge of syntactic elements of language is necessary to a full understanding of semantic memory. Moreover, the experiment also shows that older subjects are able to use syntactic redundancy to distinguish between "new" and "given" information at least as well and possibly better than younger subjects. This finding suggests that the learned use of syntactic redundancy in language may be able to compensate to some extent for memory deficits which occur with age.

In Experiment II, the model used in the analysis of variance of sentences and constructions considers language to be a fixed effect. As can be seen in Table 2, all the F-ratios except for Age are less than 1.00, an indication that perhaps the fixed effects model used is not appropriate for these data. However, consideration of the data using a random effects model does not change the results. The remaining possibility is that there is an inflated Age x Sentences x Construction interaction.

Wike and Church (1976), in their analysis of Clark's (1973) argument, point out that Clark uses definitions of "random" and "fixed" which differ from the traditional definitions on which the method of analysis of variance is based. Specifically, the traditional definition of "fixed" includes the possibility that the levels chosen are less than all possible levels ($p < P$) as long as the levels are chosen in some systematic way. Clark, on the other hand, defines $p \ll P$ as random regardless of the mode of selection. Therefore, in order to use the present method of analysis of variance, language variables should be treated as fixed effects since the materials used were chosen systematically. Moreover, examination of data in Table 2 treated as mixed with one and/or two variables (sentences and/or constructions) treated as random all lead to the same conclusion. Therefore the more important consideration is whether the error term is inflated.

The results of Experiment II show that syntactic elements of the language can have effects on memory and also that syntactic elements may have differential effects due to age. Such findings have important implications for memory research, since they point out a number of language variables which need to be considered before a complete understanding of the structure of semantic memory can be reached. Various types of syntactic and semantic redundancy, as well as other syntactic elements, need to be investigated to determine both the specific effects of each on memory and also any compensatory role each might play in memory among older subjects.

It is possible that older subjects might use redundancy rules even when they are not appropriate if such rules sometimes serve to compensate for memory deficits. For example, Haviland and Clark (1974) suggest that Bransford and Franks' (1971) subjects remembered networks of propositions rather than specific sentences because the sentences were linked presuppositionally by the use of "the." Comparing the performance of different-aged subjects when "the" is or is not present in the sentences to determine whether such a weak presuppositional clue is used to a greater extent by older subjects, or even whether they integrate sentences more than younger subjects when "the" is not present, could provide greater insight into how semantic memory is structured. A finding that older subjects use redundancy rules inappropriately could indicate that the structure of semantic memory changes with age, resulting in discrepancies between older and younger subjects which are not due to deficits in encoding or retrieval ability.

APPENDIX I

INSTRUCTIONS FOR EXPERIMENT I

The first slide you see will have a single letter printed on it. The second slide will have a string of eight letters. I want you to decide whether or not the single letter appears in the letter string. If it does, press the switch here [indicating right side] with your right hand for "yes." If the letter does not appear in the string, press the switch here with your left hand for "no." I want you to be sure you are right before pressing the switch, but after you have made the decision, press the switch as quickly as possible. Sit up to the table so you are comfortable having both hands on the switches. Remember, the decision is of primary importance, but then speed is also important.

APPENDIX 2

LIST OF LETTERS AND EIGHT-LETTER STRINGS

Letter String	Letter	Order
NEGMFCUH	N	1
EDSITHAL	S	3
QTPZIFMV	E	0
FKMITPSC	H	0
PZQVKUGF	K	0
EDSTHOUL	Y	2
ANSTRIGH	O	3
XASTYINE	X	2
CALFROVE	R	3
HCQXSAWV	W	0
BWAENYRI	R	1
HWPTFNCA	Q	0
DOIELMST	O	1
MOUTSELY	G	3
PSTHORID	E	2
OBNMELDH	U	1
KZBQEMFV	V	0
INYBEIAL	Y	3
DESTRUNG	A	3
SITHORAN	V	2
YUMADTRP	W	1
OKTAIUPS	I	1
NJKEMLDX	G	0
WATHIPRE	W	2
CBINGSYJ	N	0
ICPEDTAB	F	1
LCAINDST	F	2
GANDEOPL	B	3
STRIDEAC	S	3
EMICHANS	M	2
TUGHAPOF	H	2
SNHELACY	X	1

APPENDIX 3

LIST OF LETTERS AND TWELVE-LETTER STRINGS

Letter String	Letter	Order	Letter String	Letter	Order
NEGMFCUHDSER	D	1	OKTAIUPSLEUN	I	1
EDSITHALMAGE	S	3	NJKEMLDXVALR	G	0
QTPZIFMVJNUW	E	0	WATHIPREMEBU	W	2
FKMITPSCAMOY	H	0	CBINGSYJHCZY	Z	0
PZQVKUGFOMSB	K	0	ICPEDTABPNFR	H	1
EDSTHOULWHEP	Y	2	LCAINDSTDSPR	F	2
ANSTRIGHSTEM	U	3	GANDEOPLBOAS	T	3
XASTYINEATHI	H	2	STRIDEACINGE	R	3
CALFROVETRAC	F	3	EMICHANSOUNG	M	2
HCQXSAWVHDFB	W	0	TUGHAPOFBUEC	A	2
BWAENYRITHEN	B	1	SNHELACYSOYW	X	1
HWPTFNCAGFZC	R	0			
DOIELMSTVNUI	L	1			
MOUTSELYNAMI	G	3			
PSTHORIDCIND	E	2			
OBNMELDHMLEI	A	1			
KZBQEMFVNDZR	V	0			
INYBEIALENCH	C	3			
DESTRUNGESPO	A	3			
SITHORANNECO	V	2			
YUMADTRPDTUO	W	1			

APPENDIX 4

BASIC SENTENCES

1. The king led the troops.
2. The boy robbed the market.
3. The animal sniffed the blood.
4. The scorpion bit the fox.
5. The nun cleaned the bowl.
6. The dove found the potato.
7. The creature attacked the cat.
8. The horse climbed the mountain.
9. The grandmother purchased the bouquet.
10. The judge crossed the avenue.
11. The painter ate the spinach.
12. The boss appointed the jury.
13. The whale amused the queen.
14. The slave dug the cellar.
15. The woman avoided the policeman.
16. The artist examined the landscape.
17. The beggar scrubbed the stain.
18. The doctor captured the lark.
19. The fisherman noticed the factory.
20. The prisoner visited the palace.
21. The teacher thanked the speaker.
22. The juggler threw the coin.

23. The infant shook the rattle.

24. The settler returned the medallion.

APPENDIX 5

PHYSICAL ACTIVITY SCALE

1. Inactive - - - - - - - - - - - - - - - - Average - - - - - - - - - - - - - - - - Very Active

APPENDIX 6

RECOGNITION LISTS

Maiden	Y	N	Spinach	Y	N
Leader	Y	N	Army	Y	N
Queen	Y	N	Fork	Y	N
Picture	Y	N	Machine	Y	N
Blood	Y	N	Nephew	Y	N
Palace	Y	N	Butterfly	Y	N
Rattle	Y	N	Slave	Y	N
Lark	Y	N	Window	Y	N
Fisherman	Y	N	Frog	Y	N
Professor	Y	N	Piano	Y	N
Restaurant	Y	N	Judge	Y	N
Bouquet	Y	N	Singer	Y	N
Gentleman	Y	N	Woman	Y	N
Loom	Y	N	Student	Y	N
Nun	Y	N	Snake	Y	N
Market	Y	N	Landscape	Y	N
Medallion	Y	N	Boss	Y	N
Tree	Y	N	Horse	Y	N
King	Y	N	Stain	Y	N
Captive	Y	N	Jelly	Y	N
Kiss	Y	N	Coin	Y	N
Scorpion	Y	N	Creature	Y	N
Dove	Y	N	Candidate	Y	N
Hammer	Y	N	Teacher	Y	N

List 1

Infant	Y	N	Whale	Y	N
Comrade	Y	N	Bowl	Y	N
Fox	Y	N	Committee	Y	N
Ship	Y	N	Butcher	Y	N
Factory	Y	N	Temple	Y	N
Troops	Y	N	Ink	Y	N
Priest	Y	N	Money	Y	N
Boy	Y	N	Cat	Y	N
Jury	Y	N	Flag	Y	N
Animal	Y	N	Artist	Y	N
Pupil	Y	N	Settler	Y	N
Beggar	Y	N	Cellar	Y	N
Apple	Y	N	Mountain	Y	N
Avenue	Y	N	Slipper	Y	N
Author	Y	N	Policeman	Y	N
Diamond	Y	N	Painter	Y	N
Banker	Y	N	Damsel	Y	N
Journal	Y	N	Prisoner	Y	N
Sauce	Y	N	Baby	Y	N
Barrel	Y	N	Wife	Y	N
Doctor	Y	N	Jail	Y	N
Speaker	Y	N	Potato	Y	N
Grandmother	Y	N	Poet	Y	N
Beast	Y	N	Juggler	Y	N

<u>List 2</u>

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